



Class: 2<sup>nd</sup>

Subject: Strength of Materials

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*Al-Mustaqbal University College*  
*Air Conditioning and Refrigeration Techniques*  
*Engineering Department*

**Strength of Materials**

**Second Stage**

**M.Sc Murtadha Mohsen Al-Masoudy**

**( 2020 – 2021 )**

  
م.س. مورتادها موهسن المسعودي



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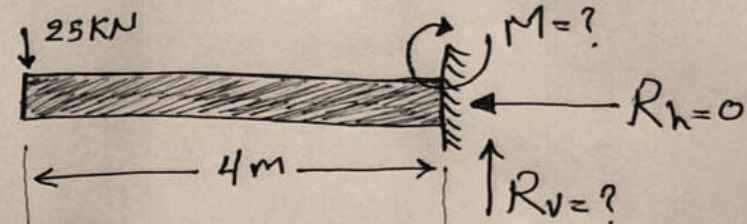
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### Shearing force & Bending moment diagrams

Ex. 1



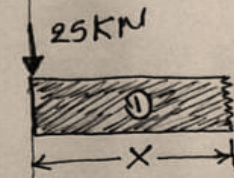
at sec. 1

$$V = -25$$

$$0 \leq x \leq 4$$

$$\text{at } x=0 \Rightarrow V = -25$$

$$\text{at } x=4 \Rightarrow V = -25$$



S.F.D

$$\sum M = 0$$

$$\therefore M = 25 \times 4$$

$$M = 100$$

KN.m

$$\sum F_y = 0$$

$$\therefore R_v = 25 \text{ kN}$$

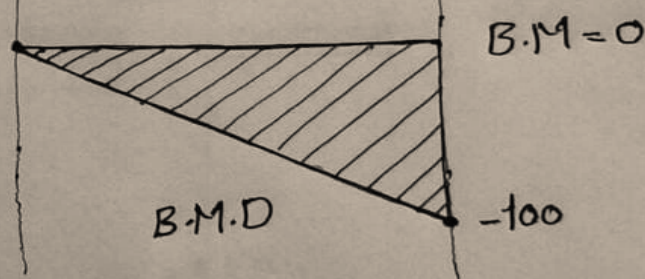
at sec. 1

$$BM_x = -25x$$

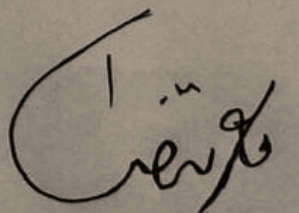
$$0 \leq x \leq 4$$

$$\text{at } x=0 \Rightarrow BM = 0$$

$$\text{at } x=4 \Rightarrow BM = -100$$



B.M.D

  
 مورتدھا المسعودي



Ex. 2

at sec. 1

$$V = -10 \text{ KN}$$

$$0 \leq x \leq 2$$

$$\text{at } x=0 \Rightarrow V = -10 \text{ KN}$$

$$\text{at } x=2 \Rightarrow V = -10 \text{ KN}$$

at sec. 2

$$V = -10 + 5$$

$$V = -5 \text{ KN}$$

$$2 \leq x \leq 4$$

$$\text{at } x=2 \Rightarrow V = -5$$

$$\text{at } x=4 \Rightarrow V = -5$$

at sec. 1

$$BM_x = -10x$$

$$0 \leq x \leq 2$$

$$\text{at } x=0 \Rightarrow BM = 0$$

$$\text{at } x=2 \Rightarrow BM = -20$$

at sec. 2

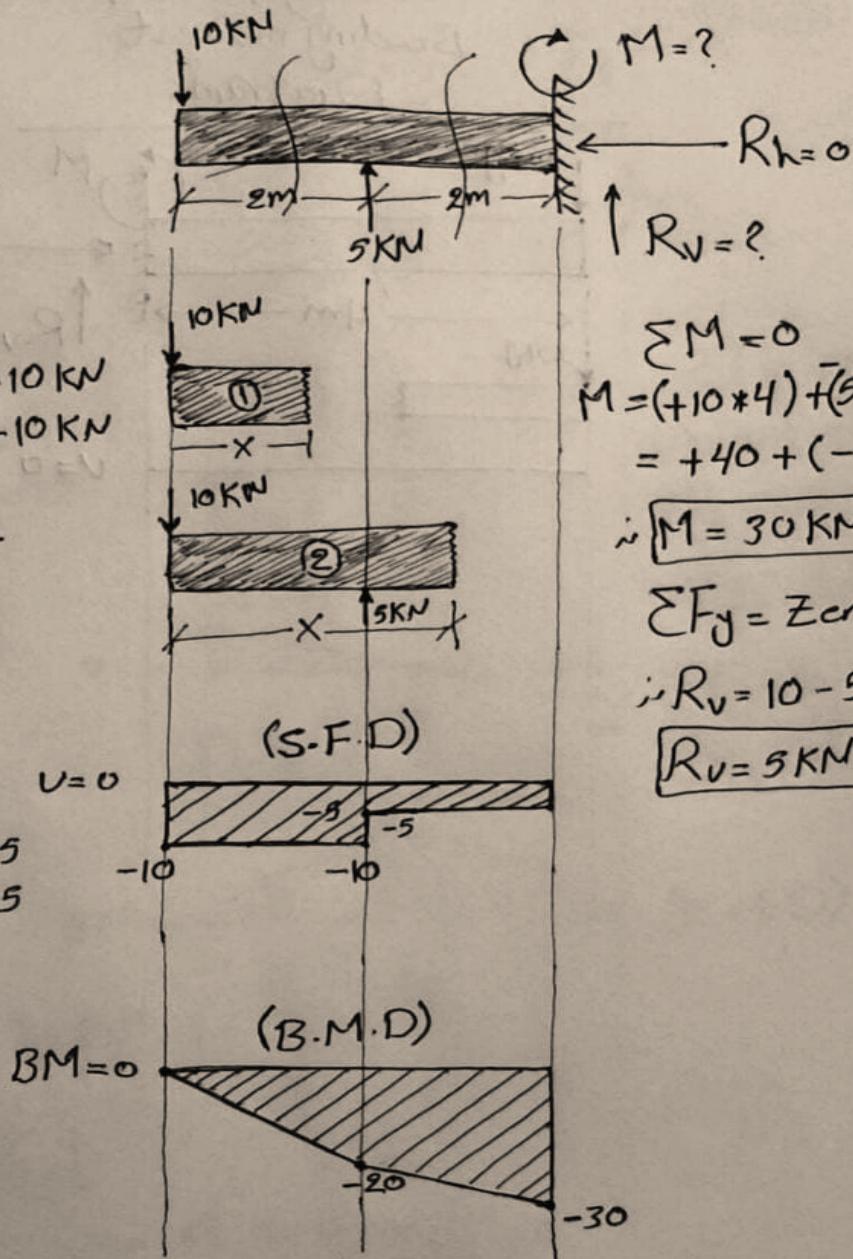
$$BM_x = -10x + [5(x-2)]$$

$$\therefore BM_x = -10x + 5x - 10$$

$$BM_x = -5x - 10$$

$$\text{at } x=2 \Rightarrow BM = -20$$

$$\text{at } x=4 \Rightarrow BM = -30$$



$$M = ?$$

$$R_H = 0$$

$$R_V = ?$$

$$\sum M = 0$$

$$M = (+10 \times 4) + (5 \times 2)$$

$$= +40 + (-10)$$

$$\therefore M = 30 \text{ KN.m}$$

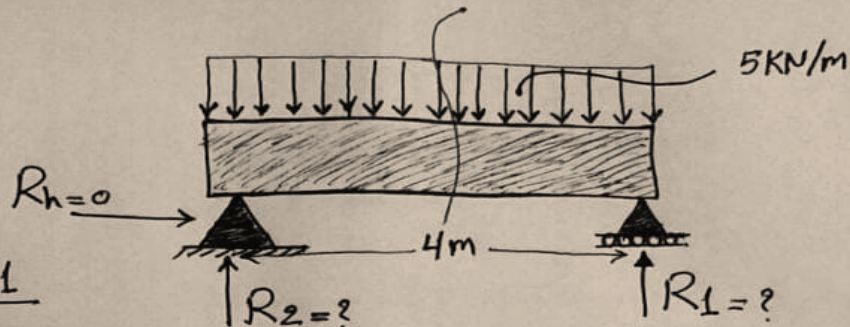
$$\sum F_y = \text{Zero}$$

$$\therefore R_V = 10 - 5$$

$$R_V = 5 \text{ KN}$$



Ex.3



at sec.1

$$V = -5X + 10$$

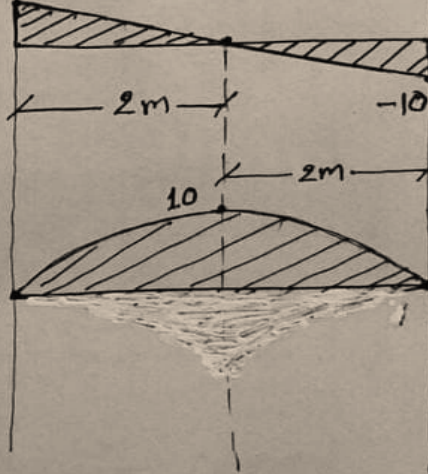
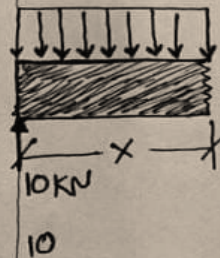
$$0 \leq X \leq 4$$

$$\text{at } X=0 \Rightarrow V=10$$

$$\text{at } X=4 \Rightarrow V=-10$$

(S.F.D)

$$V=0$$



$$\sum M_{R_1} = 0$$

$$(R_2 \times 4) - [5 \times 4] \times 2 = 0$$

$$4R_2 = 40$$

$$\therefore R_2 = 10 \text{ kN}$$

$$\sum F_y = 0$$

$$\therefore R_1 = 10 \text{ kN}$$

at sec.1

$$BM_x = -5X\left(\frac{X}{2}\right) + 10X$$

$$= -5\frac{X^2}{2} + 10X$$

$$\therefore BM_x = -\frac{5}{2}X^2 + 10X$$

$$0 \leq X \leq 4$$

$$\therefore \text{at } X=0 \Rightarrow BM=0$$

$$\text{at } X=4 \Rightarrow BM=0$$

$$\text{at } X=2 \Rightarrow BM=10$$

(B.M.D)



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Ex. 4

at sec. 1

$$U = 24 \text{ KN}$$

$$0 \leq x \leq 2$$

$$\text{at } x=0 \Rightarrow U = 24$$

$$\text{at } x=2 \Rightarrow U = 24$$

at sec. 2

$$U = 24 - [30(x-2)]$$

$$= 24 - 30x + 60$$

$$\therefore U = 84 - 30x$$

$$2 \leq x \leq 4$$

$$\text{at } x=2 \Rightarrow U = 24$$

$$\text{at } x=4 \Rightarrow U = -36$$

at sec. 3

$$U = 24 - [30(2)]$$

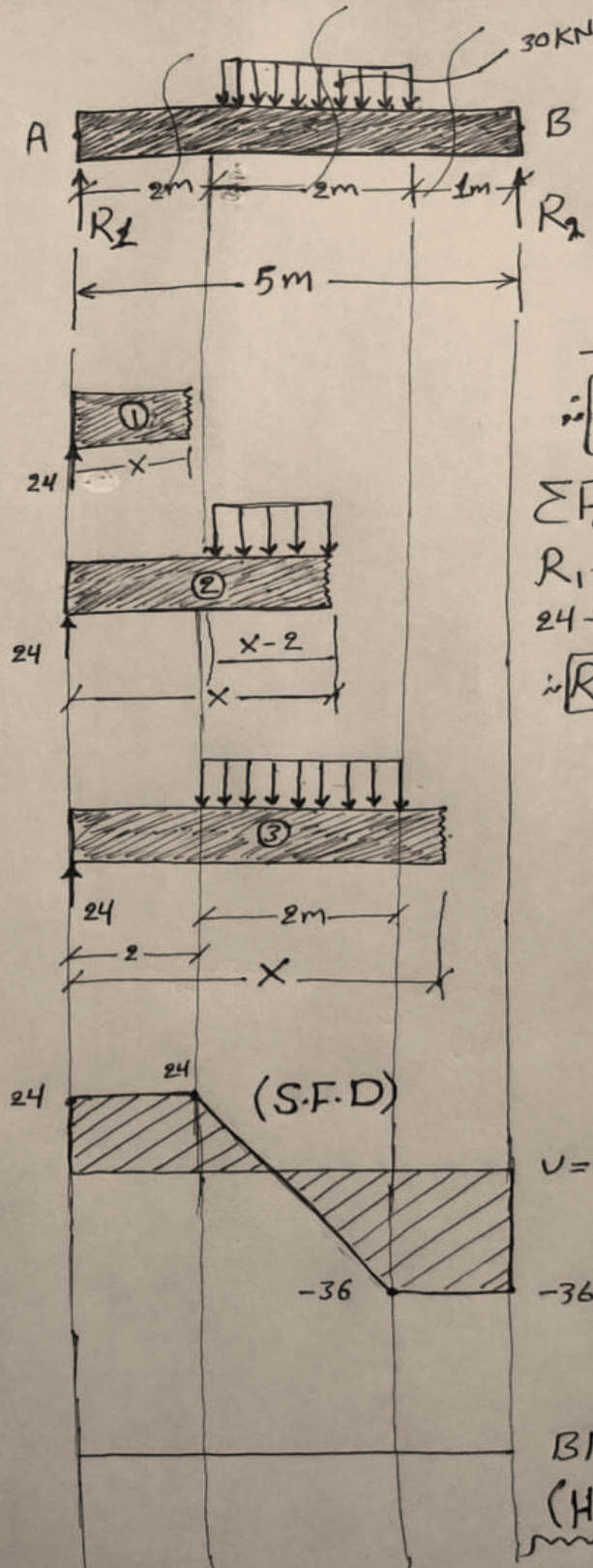
$$U = 24 - 60$$

$$U = -36 \text{ KN}$$

$$4 \leq x \leq 5$$

$$\text{at } x=4 \Rightarrow U = -36$$

$$\text{at } x=5 \Rightarrow U = -36$$



$$\sum M_D = 0$$

$$-R_1 \times 5 + [(2 \times 30) \times 2] = 0$$

$$\therefore R_1 = \frac{120}{5} = 24 \text{ KN}$$

$$\sum F_y = 0$$

$$R_1 + R_2 = 60$$

$$24 + R_2 = 60$$

$$\therefore R_2 = 36 \text{ KN}$$

BM = 0  
(Homework)





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Ex.5

at sec.1

$$V = 5 \text{ KN}$$

$$0 \leq x \leq 3$$

$$\text{at } x=0 \Rightarrow V=5$$

$$\text{at } x=3 \Rightarrow V=5$$

at sec.2

$$V = 5 - 10 = -5$$

$$3 \leq x \leq 6$$

$$\text{at } x=3 \Rightarrow V=-5$$

$$\text{at } x=6 \Rightarrow V=-5$$

at sec.1

$$M_x = 5x \text{ KN}\cdot\text{m}$$

$$0 \leq x \leq 3$$

$$\text{at } x=0 \Rightarrow M_x=0$$

$$\text{at } x=3 \Rightarrow M_x=15$$

at sec.2

$$M_x = 5x - 10(x-3)$$

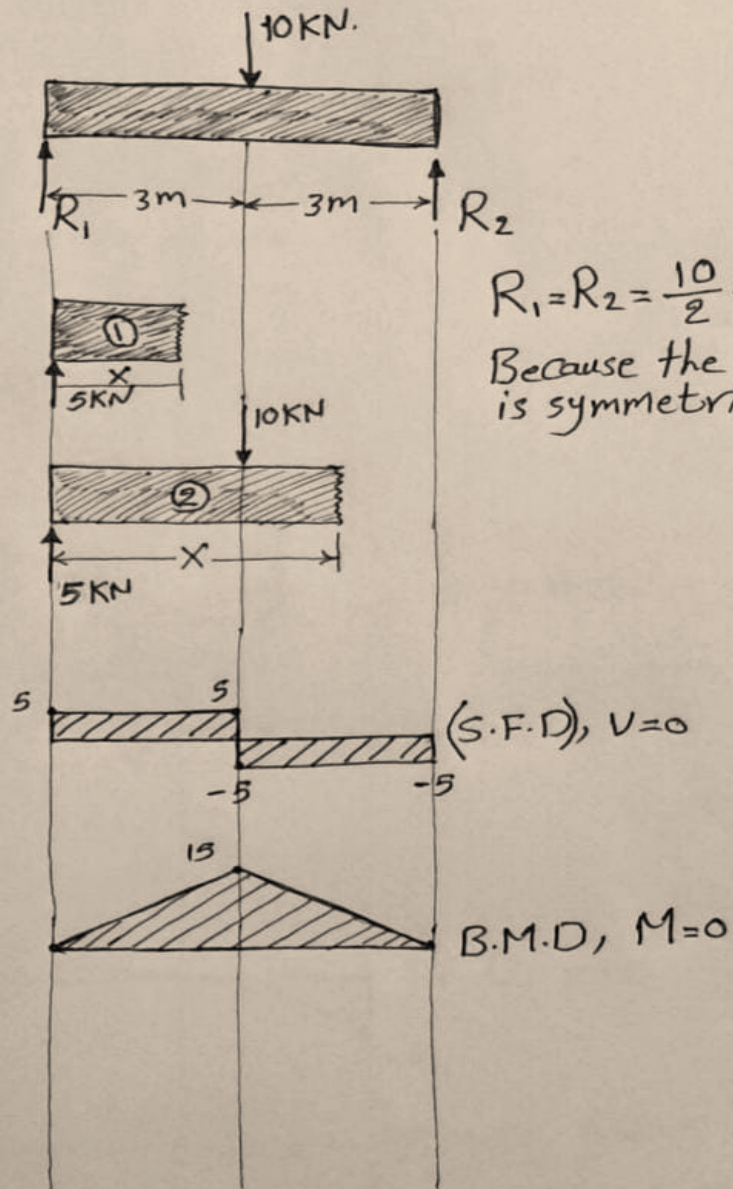
$$= 5x - 10x + 30$$

$$M_x = -5x + 30 \text{ KN}\cdot\text{m}$$

$$3 \leq x \leq 6$$

$$\therefore \text{at } x=3 \Rightarrow M_x=15$$

$$\text{at } x=6 \Rightarrow M_x=0$$



$$R_1 = R_2 = \frac{10}{2} = 5$$

Because the beam is symmetric.

(S.F.D),  $V=0$

B.M.D,  $M=0$



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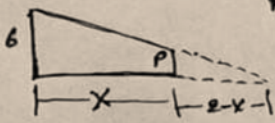
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Ex. 6

at sec. 1

$$V = 6 - \left[ \frac{6 + (6 - 3x)}{2} \cdot x \right]$$



$$\frac{p}{6} = \frac{2-x}{2}$$

$$\therefore p = 6 - 3x$$

OR

$$V = \left[ (6 - 3x)x + \frac{6 - (6 - 3x)}{2} \cdot x \right]$$

$$\therefore 0 \leq x \leq 2$$

$$\text{at } x=0 \Rightarrow V=6$$

$$\text{at } x=2 \Rightarrow V=0$$

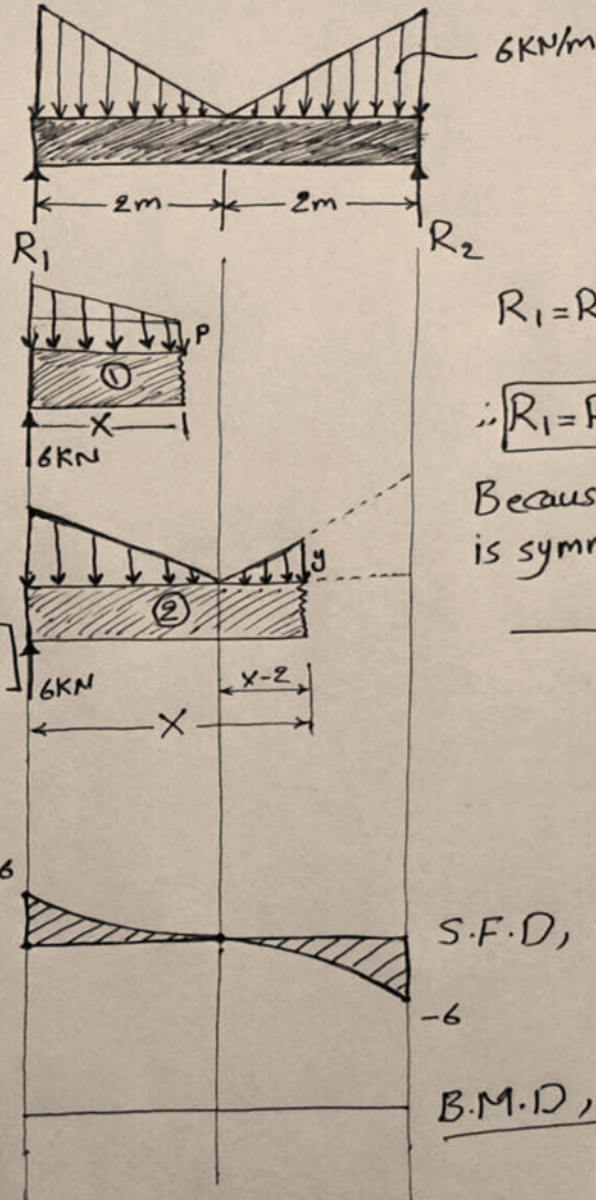
at sec. 2

$$\frac{y}{6} = \frac{x-2}{2}$$

$$\therefore y = 3x - 6$$

$$V = 6 - \frac{6 \times 2}{2} - \frac{(3x-6)(x-2)}{2}$$

$$2 \leq x \leq 4$$



$$R_1 = R_2 = \frac{6 \times 2 \times 2}{2}$$

$$\therefore R_1 = R_2 = 6 \text{ kN}$$

Because the beam is symmetric.

S.F.D,  $V=0$

-6

B.M.D,  $BM=0$

Homework

$$\therefore \text{at } x=2 \Rightarrow V=0$$

$$\text{at } x=4 \Rightarrow V=-6$$



Ex. 7

$$\begin{aligned} \textcircled{+} \sum M_{R_2} &= \text{Zero} \\ -3R_1 + \left[ \left( \frac{6 \times 3}{2} \right) \times \frac{1}{3} \times 3 \right] &= 0 \\ \therefore R_1 &= 3 \text{ KN} \end{aligned}$$

$$\begin{aligned} \sum F_y &= 0 \\ R_1 + R_2 &= \frac{6 \times 3}{2} \\ \therefore R_2 &= 6 \text{ KN} \end{aligned}$$

at sec. 1

$$BM_x = 3x - \left[ \frac{Px}{2} \times \frac{x}{3} \right]$$

$$\text{but } \frac{P}{6} = \frac{x}{3}$$

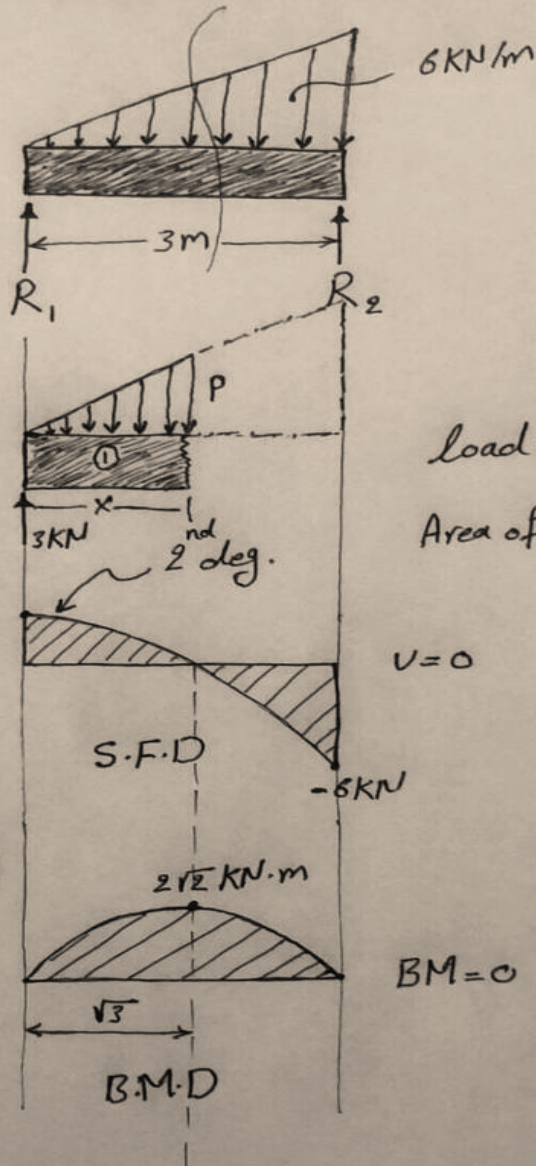
$$\therefore P = 2x$$

$$\therefore BM_x = 3x - \left[ \frac{x^3}{3} \right]$$

$$0 \leq x \leq 3$$

$$\therefore \text{at } x=0 \Rightarrow BM_x = 0$$

$$\text{at } x=3 \Rightarrow BM_x = 0$$



$$\text{shear}(V) = \frac{dm}{dx}$$

$$\frac{dm}{dx} = 0$$

$$3 - \frac{3x^2}{3} = 0$$

$$\therefore x = \sqrt{3} \text{ m} \Rightarrow BM_{\text{max}} = 2\sqrt{3} \text{ KN.m}$$



Ex. 8

$$\sum M_{R_1} = \text{Zero}$$

$$5R_2 - 60 - \left[ (20 \times 3) \times \frac{3}{2} \right] + 30 \times 1 = 0$$

$$\therefore R_2 = 24 \text{ KN}$$

$$\sum F_y = \text{Zero}$$

$$\therefore R_1 = 66 \text{ KN}$$

$$\text{load} = \frac{dV}{dx}$$

$$V = \frac{dM}{dx}$$

M = Area of the shear

$$\frac{24}{x} = \frac{36}{3-x}$$

$$\therefore x = \frac{24}{20} \text{ m}$$

$$\therefore BM_a = -30 + \frac{26 \times \left(3 - \frac{24}{20}\right)}{2}$$

$$= +2.4 \text{ KN}\cdot\text{m}$$

$$BM_b = +2.4 - \frac{x + 24}{2}$$

$$= 2.4 - \frac{\frac{24}{20} + 24}{2}$$

$$= -12 \text{ KN}\cdot\text{m}$$

$$BM_c = -12 - (24 \times 1) = 36 \text{ KN}\cdot\text{m}$$

